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Mary Ronan Lake, Lake County, Montana

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

May 77

PB 270 635

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NATIONAL EUTROPHICATION SURVEY

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16. ABSTRACT:

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
MARY RONAN LAKE
LAKE COUNTY
MONTANA
EPA REGION VIII
WORKING PAPER No. 796

WITH THE COOPERATION OF THE
MONTANA DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES
AND THE
MONTANA NATIONAL GUARD
MAY, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nation-wide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

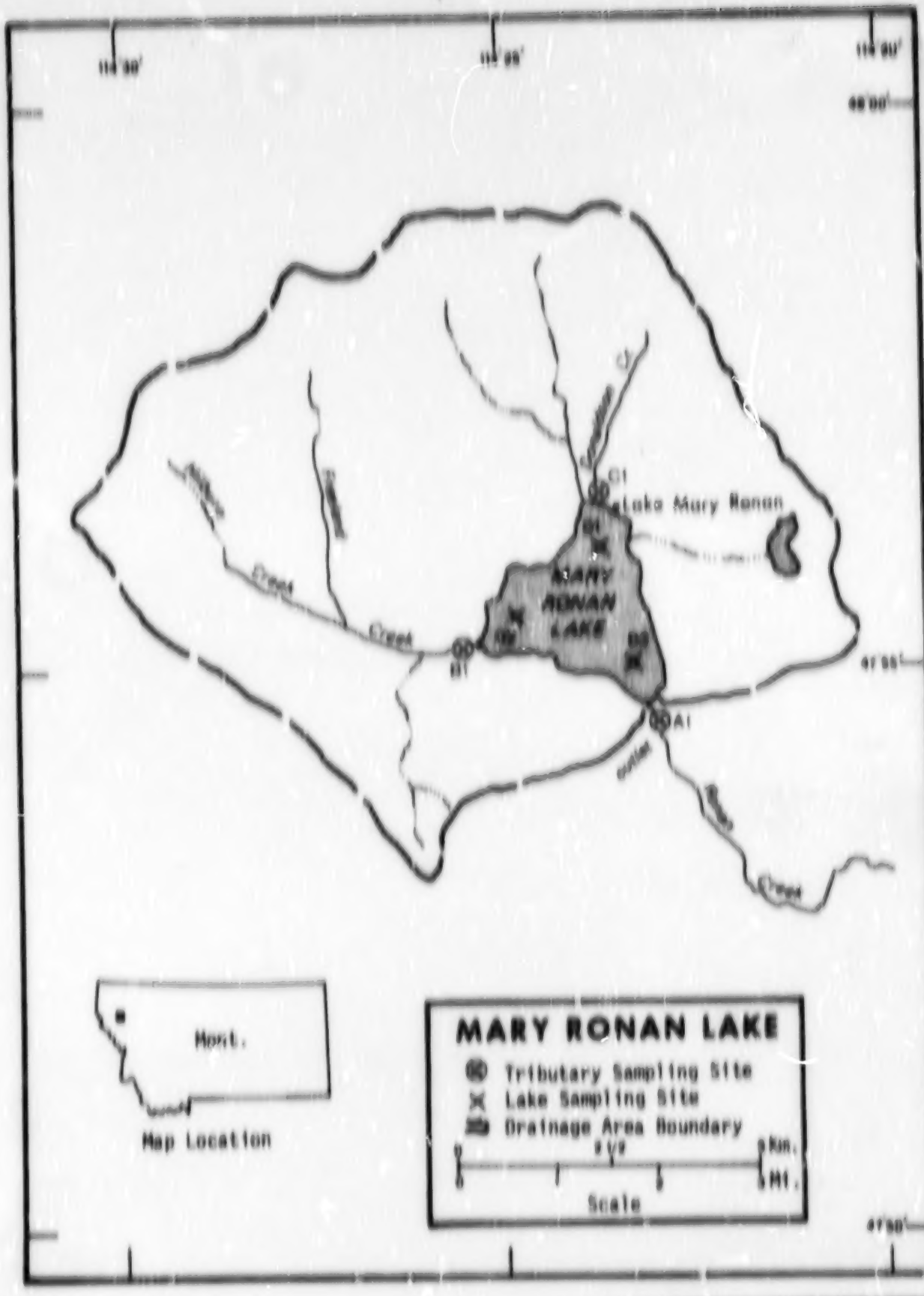
The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS
STATE OF MONTANA

LAKE NAME	COUNTY
Canyon Ferry	Broadwater, Lewis and Clark
Clark Canyon	Beaverhead
Flathead	Flathead, Lake
Georgetown	Deer Lodge, Granite
Hebgen	Gallatin
Koocanusa	Lincoln, MT; British Columbia, Can.
Mary Ronan	Lake
McDonald	Flathead
Nelson	Phillips
Seeley	Missoula
Swan	Lake
Tally	Flathead
Tiber	Liberty, Toole
Tongue River	Big Horn
Whitefish	Flathead
Yellowtail	Carbon, Bighorn, MT; Bighorn, WY


114°30'
114°25'
114°20'
48°00'
47°55'
47°50'
C1
Lake Mary Ronan
MARY RONAN LAKE
Creek
A1
Creek
Mont.
Map Location
MARY RONAN LAKE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 1/2 1 2 Km.
0 1 2 Mi.
Scale

MARY RONAN LAKE

STORET NO. 3007

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Mary Ronan Lake is meso-eutrophic. It ranked seventh in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six lake parameters*. Seven of the water bodies had less median total phosphorus, none had less and four had the same median inorganic nitrogen, six had less median dissolved orthophosphorus, ten had less mean chlorophyll *a*, and nine had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at station 1 in September.

Survey limnologists reported the occurrence of macrophytes at station 1 and observed surface concentrations of algae in October.

B. Rate-Limiting Nutrient:

Due to significant nutrient changes in the algal assay samples during shipment from the field to the laboratory, the results are not considered representative of conditions in the lake at the times of sampling.

The lake data indicate nitrogen limitation all four sampling times.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial wastewater treatment plants impacted the lake during the sampling year. Septic tanks serving lakeshore dwellings were estimated to have contributed 1.3% of the total phosphorus load, but a shoreline survey would be necessary to determine the actual significance of those sources.

The present phosphorus loading of 0.10 $g/m^2/yr$ is a little more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12).

2. Non-point sources--Non-point sources, including direct precipitation, accounted for 98.7% of the total phosphorus load to the lake during the sampling year. Freeland Creek contributed 29.9% of the total load; Donaldson Creek, 27.7%; and the ungaged tributaries added an estimated 31.3% of the total.

The phosphorus export rates of Freeland and Donaldson creeks were 11 and 54 $kg/km^2/yr$, respectively (see page 11). The cause of the much higher rate of Donaldson Creek is not known, but it may have resulted from insufficient sampling.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 6.15 kilometers².
2. Mean depth: 8.5 meters.
3. Maximum depth: 14.3 meters.
4. Volume: 52.275 x 10^6 m^3.
5. Mean hydraulic retention time: 17.4 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Freeland Creek	31.8	0.060
Donaldson Creek	6.7	0.046
Minor tributaries & immediate drainage -	33.1	0.004
Totals	70.6	0.110

2. Outlet -

Ronan Creek	76.8**	0.095

C. Precipitation***:

1. Year of sampling: 51.4 centimeters.
2. Mean annual: 69.0 centimeters.

† Table of metric conversions--Appendix B.
†† Surface area determined by planimetry; mean depth from Norpested (1975).
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Mary Ronan Lake was sampled four times during the open-water season of 1975 by means of a pentoca-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake in June, July, and September (two stations in October) and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first, third and last visits, a single 15.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 11.0 meters at station 1, 11.6 meters at station 2, and 7.6 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A SUMMARY OF MEDICAL AND CHEMICAL CHARACTERISTICS FOR HOPE RIVER LAKE
STUDY CASE 387

1ST SAMPLING (07 2/75)

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	6.4 - 13.7	10.4	10.4
DISS OXY (MG/L)	5.6 - 10.4	8.1	10.0
CNDCTVY (MICROMO	96. - 133.	95.	94.
PH (STAND UNITS)	7.5 - 8.4	8.1	8.1
TOT ALK (MG/L)	58. - 84.	74.	80.
TOT P (MG/L)	0.020 - 0.024	0.021	0.022
NITRO P (MG/L)	0.005 - 0.009	0.007	0.003
AMMONIA (MG/L)	0.005 - 0.009	0.006	0.005
AMMONIA (MG/L)	0.000 - 0.040	0.020	0.020
KJEL N (MG/L)	0.400 - 0.480	0.420	0.400
NITRO N (MG/L)	0.040 - 0.060	0.050	0.050
TOTAL N (MG/L)	0.400 - 0.420	0.540	0.520
CHLOPHYL A (UG/L)	5.0 - 5.7	5.4	5.6
SECCHI (METERS)	3.4 - 3.6	3.4	3.4

2ND SAMPLING (7/30/75)

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	6.0 - 25.4	17.2	24.0
DISS OXY (MG/L)	2.0 - 9.6	7.1	7.0
CNDCTVY (MICROMO	96. - 125.	111.	113.
PH (STAND UNITS)	7.5 - 8.0	8.5	8.7
TOT ALK (MG/L)	54. - 72.	62.	62.
TOT P (MG/L)	0.004 - 0.021	0.014	0.012
NITRO P (MG/L)	0.003 - 0.013	0.005	0.004
AMMONIA (MG/L)	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.020 - 0.060	0.020	0.020
KJEL N (MG/L)	0.300 - 0.720	0.540	0.480
NITRO N (MG/L)	0.040 - 0.070	0.040	0.050
TOTAL N (MG/L)	0.320 - 0.720	0.460	0.520
CHLOPHYL A (UG/L)	3.2 - 4.7	3.7	3.2
SECCHI (METERS)	3.0 - 4.5	5.0	4.1

3RD SAMPLING (07 9/75)

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	13.3 - 17.1	16.1	16.3
DISS OXY (MG/L)	6.0 - 6.8	7.0	6.7
CNDCTVY (MICROMO	105. - 125.	116.	117.
PH (STAND UNITS)	7.8 - 8.0	8.0	8.7
TOT ALK (MG/L)	64. - 66.	65.	65.
TOT P (MG/L)	0.015 - 0.018	0.018	0.017
NITRO P (MG/L)	0.002 - 0.007	0.004	0.003
AMMONIA (MG/L)	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.020 - 0.060	0.020	0.020
KJEL N (MG/L)	0.300 - 0.360	0.405	0.350
NITRO N (MG/L)	0.040 - 0.040	0.040	0.040
TOTAL N (MG/L)	0.320 - 0.360	0.440	0.370
CHLOPHYL A (UG/L)	3.0 - 3.1	3.0	3.0
SECCHI (METERS)	2.5 - 2.3	3.0	2.5

| | | |

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/02/75	1. Dinobryon sp.	2,787
	2. Cryptomonas sp.	190
	3. Microcystis sp.	127
	4. Aphanizomenon sp.	95
	5. Fragilaria sp.	95
	Other genera	126
	Total	3,420
07/28/75	1. Aphanizomenon sp.	245
	2. Fragilaria sp.	163
	3. Cryptomonas sp.	163
	4. Chroomonas sp.	163
	5. Anabaena sp.	82
	Other genera	124
	Total	940
09/05/75	1. Chroomonas sp.	373
	2. Aphanothece sp.	217
	3. Anabaena sp.	155
	4. Cryptomonas sp.	155
	5. Aphanizomenon sp.	93
	Other genera	32
	Total	1,025
10/22/75	1. Aphanizomenon sp.	851
	2. Cryptomonas sp.	675
	3. Microcystis sp.	294
	4. Chroomonas sp.	204
	5. Fragilaria sp.	176
	Other genera	441
	Total	2,700

F. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
06/02/75	1	5.0
	2	5.5
	3	6.7
07/28/75	1	3.6
	2	4.2
	3	3.8
09/05/75	1	1.1
	2	0.9
	3	1.0
10/22/75	1	4.9
	2	[illegible]
	3	16.2

G. Limiting Nutrient Study:

Due to significant changes in nutrients in the algal assay samples during shipment from the field to the laboratory, the results are not considered representative of conditions in the lake at the time of sampling.

The lake data indicate nitrogen limitation at all sampling times. The mean inorganic nitrogen to orthophosphorus ratios were 4 to 1 in June, 10 to 1 in July and September, and 13 to 1 in October; and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS (See Appendix E for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of June when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Montana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station 6-1, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

No known wastewater treatment plants impacted Mary Ronan Lake during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

* See Working Paper No. 175.

B. Annual total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr.	% of total
a. Tributaries (non-point load) -		
Freeland Creek	335	29.9
Donaldson Creek	810	67.7
b. Minor tributaries & immediate drainage (non-point load) -	350	31.3
c. Known municipal STP's - None	-	-
d. Septic tanks* -	15	1.3
e. Known industrial - None	-	-
f. Direct precipitation** -	110	9.8
Total	1,120	100.0

2. Outputs -

Lake outlet - Nunan Creek 490

3. Net annual P accumulation - 630 kg.

* Estimate based on 50 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Freeland Creek	2,665	15.3
Donaldson Creek	4,760	27.4
b. Minor tributaries & immediate drainage (non-point load) -	2,775	16.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	535	3.1
e. Known industrial - None	-	-
f. Direct precipitation** -	6,640	38.2
Total	17,375	100.0

2. Outputs -

Lake outlet - Ronan Creek 8,520

3. Net annual N accumulation - 8,855 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Freeland Creek	11	84
Donaldson Creek	64	836

* Estimate based on 50 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.18	0.10	2.8	1.4

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Mary Ronan Lake:

"Dangerous" (eutrophic loading)	0.14
"Permissible" (oligotrophic loading)	0.07

V. LITERATURE REVIEWED

Harpested, Abe, 1975. Personal communication (lake morphometry). MT Dept. of Health & Env. Sci., Helena.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

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LAKES RANKED BY [illegible]

RANK	LAKE CODE	LAKE NAME	[illegible]
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12	[illegible]	[illegible]	[illegible]
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14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

APPENDIX B

TRIBUTARY DATA

[illegible]

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